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Special Report

Geophysical Activity in 1989

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Geophysical Activity Committee

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Special Report
Geophysical Activity in 1989

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Report of the SEG Geophysical Activity Committee. Members of the Committee are Karen Goodfellow, Chairman; and Jesus A. Bilbao, Dana Cain, Charles E. Curtis, Harry Espey, Lin Evans, Ronald Hartman, R. J. Henderson, Dan D. Hollis, Richard Hopkins, W. W. (Bill) Krauter, Fritz P. Kronberger, Dennis P. Kucinskas, Robert C. Lucas, Wes Meyers, Gerald E. Montgomery, Russell J. Senti, James Sides, Mike Spradley, Frank Stirling, Paul Stoffa, and Don Watts.

Introduction

This special report represents statistical data collected worldwide in 1989. Survey questionnaires were mailed to 460 oil companies, contractors, government agencies, and universities throughout the free world. From those mailed, 209 questionnaires were returned. This is a 22 percent decrease from the 269 returned in 1988 and compares to 218 in 1987 and 251 for the 1986 report. The data represent information from all users of geophysical techniques for petroleum, mining, groundwater, and geothermal exploration and for all who employ geophysical methods in engineering, environmental, oceanography, and research.

Detailed data were gathered on airborne, drill-hole, land, marine, and transition zone geophysical surveys. Statistics were compiled on miles of coverage, number of stations, drill-hole footage, time reported in crew-months or man-months, and acquisition costs. Data not supplied on the questionnaires by the respondents were estimated on the basis of statistical averaging for the area and techniques reported. This process is necessary to avoid distortion of individual statistical items.

Comparing this report to past annual reports provides a basis for detecting and analyzing trends in technological developments and exploratory trends in geographical areas. Changes in these trends reflect the influence of factors such as oversupply of a particular natural resource, technological advances and changes in economic conditions, governmental regulations, production controls, and exploration philosophy. Cost figures are also sensitive to many factors such as operational environment, length and nature of survey, type of instrumentation, etc. Unit costs reported by universities and governments are substantially lower

Table 1. Total worldwide expenditures during 1989 in US$ (thousands) by survey type and objective.

	Petroleum[1]									
Type	Exploration	Development	Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
Land	943,185	65,414	21,254	226	13,321	1,241	1,616		2,272	1,048,529
Transition zone	32,938	4,292								37,230
Marine	701,256	61,804	183		16,414			5,020	7,578	792,255
Airborne	19,605		14,885	49	26	144	321		520	35,550
Drill hole	879	268	275		30	2	73		51	1,578
Total	1,697,863	131,777	36,598	276	29,791	1,386	2,010	5,020	10,421	1,915,142

[1]Includes processing and interpretation costs for land and marine. See text for details.

Note: All tables in this report where figures are expressed in thousands of dollars have been rounded off as individual items; but the computer keeps track of all the truncated numbers and then the sums of the individual items are rounded off. As a result of this procedure, the rounded individual items may not add up precisely to the rounded sums.

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Table 2. Total worldwide expenditures during 1989 in US$ (thousands) by area and survey objective.

Area	Petroleum[1]		Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
	Exploration	Development								
International		4,750			20		840	4,941	3,578	14,129
U.S.A.	325,160	40,549	3,255	198	1,345	493	484	19	3,872	375,375
Canada	218,862	2,012	5,128	30	1,868	2	21		421	228,343
Mexico	18,593									18,593
South America	149,171	3,721				205			10	153,107
Europe	290,176	39,140	6,901		9,439	154	95		786	346,691
Africa	311,949	18,730	11,869	19	1,024	80	149		1,530	345,349
Middle East	126,106	9,623			12,010	300				148,039
Far East	178,017	3,147	4,798		4,044	153	354	60		190,572
Australia/ New Zealand	79,828	10,105	4,648	29	41		67		225	94,943
Total	1,697,863	131,777	36,598	276	29,791	1,386	2,010	5,020	10,421	1,915,142

[1]Includes processing and interpretation costs for land and marine. See text for details.

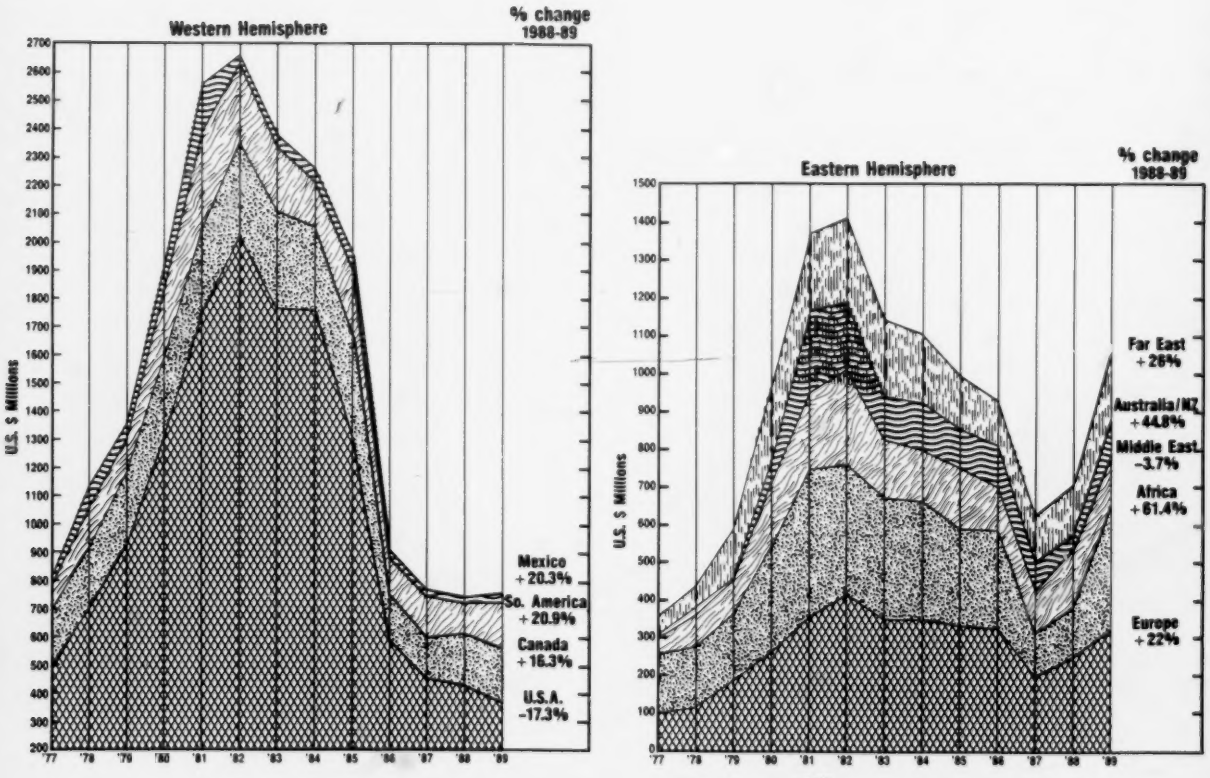

FIG. 1. Total expenditures on petroleum exploration and development, 1977-89.

than those reported by industry due to use of student labor, donated equipment, and governmental regulations. These costs, however, must be averaged with industry costs to accommodate the format of the report. Therefore, when examining unit cost figures, one must be aware of the broad spectrum of activity embraced by individual categories.

1989 highlights

Worldwide expenditures on geophysical exploration in 1988 were up 19 percent from 1988 (see Table 1). The increase was primarily in the petroleum industry where total petroleum expenditures increased by 8.6 percent. Petroleum exploration expenditures rose by 16 percent while those for petroleum development showed an even larger increase of 71.7 percent over 1988 levels. The use of geophysics for petroleum development for land activity increased by 73 percent where petroleum exploration for land increased by 3 percent. Total marine activity was up 35 percent over last year. Marine development activity rose 70.5 percent, whereas marine exploration activity increased 32 percent. Development costs for marine represents 8 percent of the total for marine expenditures while land development represents only 6.5 percent of total land expenditures.

Overall, total petroleum expenditures were at the same level as last year, 94.5 percent of the total for 1989. Petroleum exploration and development were up 16 percent and 71.7 percent, respectively, as well as engineering, up 53 percent and oceanography, up 17.5 percent were among the positive side. However, minerals (−7 percent), environmental (−61 percent), geothermal (−57 percent), groundwater (−20 percent), and research (−51 percent) all showed decreases in activity. The large fluctuation may be due to underreporting this year from past years.

Distribution of expenditures by geographic area and survey objective is shown in Table 2. Only 19.6 percent of all expenditures for geophysical work was spent in the U.S., compared to 29.3 percent in 1988, 31.8 percent in 1987, 32.6 percent in 1986, and 44 percent in 1985. However, the following areas showed an increase in total geophysical expenditures compared to 1988: Canada (+16.3 percent), Mexico (+20.3 percent), South America (+20.9 percent), Europe (+22.2 percent), Africa (+61.4 percent), Far East (+26.6 percent), and Australia/New Zealand (+44.8 percent). The U.S. showed a 17.3 percent decrease in 1989 over 1988. The Middle East decreased by 3.7 percent and International by 15.5 percent over 1988.

The costs of processing and interpretation are included in Figure 1 and the petroleum columns of Tables 1 and 2. The remaining columns in Tables 1 and 2 and all of Tables 3-17 show acquisition costs only. Average costs of processing and interpretation were obtained from the various processing contractors and oil companies to arrive at a figure of US$450.00 per line-mile last year. In order to compare acquisition costs between 1988 and 1989, processing and interpretation costs were kept constant.

Petroleum exploration

Over 94 percent of all geophysical dollars were spent on petroleum exploration (US$1.830 billion). Expenditures for petroleum exploration and development declined in the following areas:

(Text continued on p. 63)

Table 3. Worldwide petroleum land seismic activity in 1989[1].

Area	Acquisition costs - US$	Line-miles	Crew-months Company*	Crew-months Contract	Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
U.S.A.	155,609,891	40,870	60.8	1,141.6	1,202.4	33	129,407	3,807
	[840,900]	[49]	[3.5]	[.3]	[3.8]	[12]	[217,286]	[16,851]
Canada	152,656,832	37,802		401.8	421.8	89	361,917	4,038
	[17,004,214]	[588]	20.0	[19.1]	[19.1]	[30]	[890,272]	[28,889]
Mexico	13,500,000	7,544		150.0	150.0	50	90,000	1,789
South America	105,546,000	23,702		375.4	375.4	63	281,156	4,453
Europe	42,476,870	14,126	29.5	251.2	280.7	50	151,324	3,006
	[2,005,268]	[339]	[6.5]	[12.0]	[18.5]	[18]	[108,392]	[5,904]
Africa	172,915,022	55,037	3.0	466.5	469.5	117	368,296	3,141
	[1,686,313]	[270]		[21.0]	[21.0]	[12]	[80,300]	[6,238]
Middle East	114,274,990	34,194		309.0	309.0	110	369,821	3,341
	[350,000]	[348]		[5.0]	[5.0]	[69]	[70,000]	[1,005]
Far East	53,990,000	16,381		219.1	219.1	74	246,417	3,295
Australia/ New Zealand	36,270,000	11,607	2.0	78.2	80.2	144	452,244	3,124
Total	847,239,605	241,265	115.3	3,392.8	3,508.1	68	241,504	3,511
	[21,886,695]	[1,596]	[10.0]	[57.4]	[67.4]	[23]	[324,391]	[13,710]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

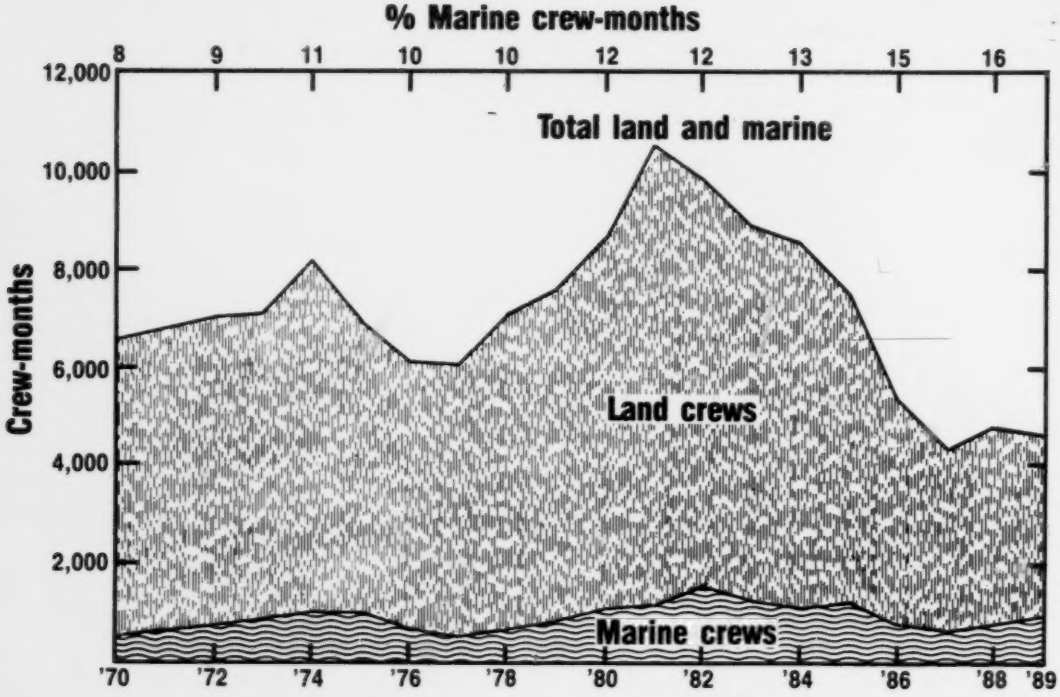

FIG. 3. Worldwide seismic activity in crew-months, 1970-89.

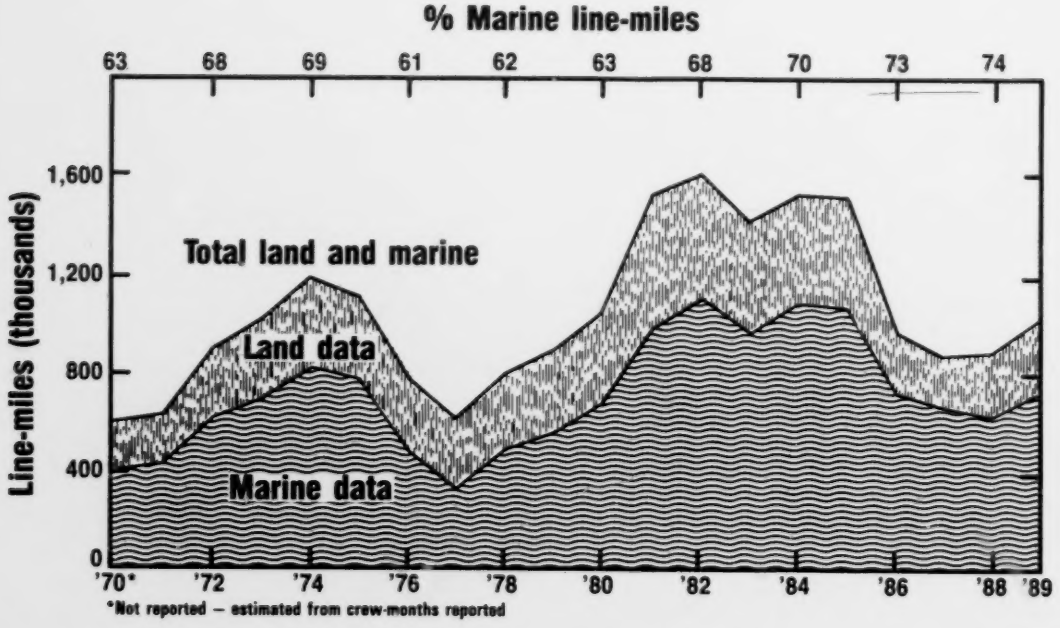

FIG. 4. Worldwide seismic activity in line-miles, 1970-89.

Table 4A. Worldwide petroleum land seismic line-miles in 1989 by energy source and 3-D survey.

Area	Dynamite	Compressed air	Weight drop	Solid chemical	Vibrator	3-D surveys Line-miles	3-D surveys Square-miles	Other	Total line-miles
U.S.A.	19,174	4	46		21,267	379	49		40,870
Canada	21,036	700	150		15,750		588	165	37,802
Mexico	1,455				6,089				7,544
South America	17,284				6,418				23,702
Europe	5,572		220		7,917	416	339		14,126
Africa	37,996	2,670		24	12,870	1,476	270		55,037
Middle East	4,757				29,436		348		34,194
Far East	12,608				2,992			781	16,381
Australia/ New Zealand	2,435				9,172				11,607
Total	122,319	3,374	416	24	111,913	2,271	1,596	946	241,265

Table 4B. Worldwide petroleum transition zone seismic activity in 1989.[1]

Area	Acquisition costs — US$	Line-miles	Crew-months Company*	Crew-months Contract	Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
U.S.A.	12,985,000	7,159	.2	25.0	25.2	283	514,257	1,813
Canada	300,000	318		.5	.5	636	600,000	943
Europe	262,630	444	11.0	1.1	12.1	36	21,704	591
Africa	3,591,615	1,655		7.9	7.9	209	454,634	2,170
Far East	1,840,000	124		5.0	5.0	24	368,000	14,838
	[7,631,000]	[125]		[8.0]	[8.0]	[15]	[953,875]	[61,048]
Total	18,979,245	9,700	11.2	39.5	50.7	191	373,975	1,956
	[7,631,000]	[125]		[8.0]	[8.0]	[15]	[953,875]	[61,048]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 5. Worldwide petroleum marine seismic activity in 1989.[1]

Area	Acquisition costs - US$	Line-miles	Crew-months Company*	Crew-months Contract	Crew-months total*	Average miles/month	Average cost/month	Average cost/mile
U.S.A.	114,852,000	197,422	51.0	147.5	198.5	994	578,599	581
	[1,450,000]	[4,328]	[1.7]		[1.7]	[2,473]	[828,571]	[335]
Canada	20,994,000	9,920		13.3	13.3	745	1,578,496	2,116
	[417,000]	[15]		[.7]	[.7]	[21]	[595,714]	[27,800]
Mexico	1,100,000	219		2.0	2.0	109	550,000	5,022
South America	23,412,000	22,955		60.0	60.0	382	390,200	1,019
Europe	210,793,000	286,478	21.0	285.0	306.0	936	688,866	735
Africa	71,780,600	103,892	2.0	154.6	156.6	663	458,222	690
Middle East	1,060,000	1,060		3.0	3.0	353	353,333	1,000
Far East	71,042,002	114,824		165.2	165.2	695	430,036	618
Australia/ New Zealand	29,814,000	40,508	2.2	24.0	26.2	1,546	1,137,938	736
Total	544,847,602	777,278	76.2	854.6	930.8	835	585,322	700
	[1,867,000]	[4,343]	[1.7]	[.7]	[2.4]	[1,772]	[762,040]	[429]

[1]All data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 6. Worldwide petroleum marine seismic line-miles in 1989 by energy source and 3-D survey.

Area	Compressed air	3-D surveys		Total line-miles
		Line-miles	Square-miles	
U.S.A.	125,772	71,650	4,328	197,422
Canada	9,920		15	9,920
Mexico	219			219
South America	22,955			22,955
Europe	141,901	144,577		286,478
Africa	78,452	25,440		103,892
Middle East	1,060			1,060
Far East	81,324	33,500		114,824
Australia/ New Zealand	40,508			40,508
Total	502,111	275,167	4,343	777,278

Table 7. Worldwide average unit costs in 1989 for petroleum surveys.

Area, survey type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew-month or man-month*	Average cost/ mile or (foot) or [station]
International						
Land						
Gravity	9.5	4,750	4,750,000	500	500,000	1,000
U.S.A.						
Land						
Seismic (*P*-wave)						
Dynamite	367.1	19,174	84,135,622	52	229,190	4,388
Compressed air	.1	4	30,000	40	300,000	7,500
Weight drop	2.0	46	230,000	23	115,000	5,000
Vibratory	821.7	21,267	65,366,269	26	79,542	3,074
Vibratory	3.0	[5]	100,000	[2]	33,333	[20,000]
3-D seismic						
Line-miles	8.5	379	5,748,000	45	676,235	15,166
Square-miles	3.8	49	840,900	13	217,287	16,852
Gravity	14.0	1,730	396,600	124	28,329	229
Gravity	1.0	[550]	30,500	[550]	30,500	[55]
Magnetic	24.0	38	5,200	2	217	137
Radiometric						
Gamma-ray	20.0	15	4,500	1	225	300
Transition zone						
Seismic (*P*-wave)						
Dynamite	13.0	304	4,265,000	23	328,077	14,030
Compressed air	7.7	2,031	3,720,000	262	480,000	1,832
3-D seismic						
Line-miles	4.5	4,824	5,000,000	1,072	1,111,111	1,036
Marine						
Seismic (*P*-wave)						
Compressed air	177.5	125,772	99,121,000	709	558,428	788
3-D seismic						
Line-miles	21.0	71,650	15,731,000	3,412	749,095	220
Square miles	1.7	4,328	1,450,000	2,473	828,571	335
Gravity	2.0	4,000	65,000	2,000	32,500	16

Table 7. Worldwide average unit costs in 1989 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
U.S.A., cont.						
Airborne						
Gravity	7.5	48,487	606,575	6,431	80,448	13
Magnetic	39.5	73,936	1,313,561	1,872	33,255	18
VLF	6.5	8,115	855,279	1,248	131,581	105
Combined EM/Mag.	4.9	6,139	736,718	1,253	150,351	120
Remote sensing						
Multispectral scanning	3.0	40,000	300,000	13,333	100,000	8
Side-looking radar	1.2	73,900	760,000	61,583	633,333	10
Drill hole						
Gravity	.5	(6,000)	42,500	(12,000)	85,000	(7)
VSPs	2.0	[6]	36,000	[3]	18,000	[6,000]
Canada						
Land						
Seismic (*P*-wave)						
Dynamite	183.3	18,336	72,426,998	100	395,020	3,950
Weight drop	1.5	150	450,000	100	300,000	3,000
Vibratory	229.2	15,750	67,129,834	69	292,824	4,262
Other	4.7	165	1,650,000	35	351,064	10,000
Seismic (refraction)						
Dynamite	2.0	2,700	8,000,000	1,350	4,000,000	2,963
Compressed air	1.0	700	3,000,000	700	3,000,000	4,286
3-D seismic						
Square miles	19.1	588	17,004,214	31	890,273	28,889
Gravity	72.0	720	36,000	10	500	50
Magnetic	5.0	10	2,500	2	500	250
Induced polarization	1.3	[95]	308,000	[73]	236,923	[3,242]
Transition zone						
Seismic (*P*-wave)						
Compressed air	.5	318	300,000	636	600,000	943
Marine						
Seismic (*P*-wave)						
Compressed air	13.3	9,920	20,994,000	746	1,578,496	2,116
3-D seismic						
Square miles	.7	15	417,000	21	595,714	27,800
Airborne						
Gravity	.2	1,361	17,026	6,805	85,130	13
Magnetic	20.7	24,836	680,165	1,200	32,858	27
VLF	26.7	33,473	3,666,663	1,254	137,328	110
Combined EM/Mag.	22.0	27,637	3,316,498	1,256	150,750	120
Mexico						
Land						
Seismic (*P*-wave)						
Dynamite	102.0	1,455	5,300,000	14	51,961	3,643
Vibratory	48.0	6,089	8,200,000	127	170,833	1,347
VSPs	12.0	[34]	500,000	[3]	41,667	[14,706]
Marine						
Seismic (*P*-wave)						
Compressed air	2.0	219	1,100,000	110	550,000	5,023

Table 7. Worldwide average unit costs in 1989 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
South America						
Land						
Seismic (*P*-wave)						
Dynamite	292.0	16,784	92,310,000	57	316,130	5,500
Vibratory	79.4	6,418	12,736,000	81	160,403	1,984
Seismic (refraction)						
Dynamite	4.0	500	500,000	125	125,000	1,000
Gravity	2.0	[1,600]	240,000	[800]	120,000	[150]
Marine						
Seismic (*P*-wave)						
Compressed air	60.0	22,955	23,412,000	383	390,200	1,020
Magnetic	14.4	28,841	230,730	2,003	16,023	8
Airborne						
Magnetic	27.3	81,700	2,173,200	2,993	79,604	27
VLF	1.0	1,228	147,269	1,228	147,269	120
Combined EM/Mag.	1.0	1,228	147,269	1,228	147,269	120
Europe						
Land						
Seismic (*P*-wave)						
Dynamite	127.1	5,572	15,830,120	44	124,549	2,841
Weight drop	15.0	220	1,309,000	15	87,267	5,950
Vibratory	127.6	7,917	22,009,750	62	172,490	2,780
3-D seismic						
Line-miles	11.0	416	3,328,000	38	302,545	7,992
Square miles	18.5	339	2,005,268	18	108,393	5,905
Gravity	18.5	4,450	2,532,000	241	136,865	569
Magnetic	12.0	[26,000]	950	[2,167]	79	[1]
Resistivity	14.0	140	280,000	10	20,000	2,000
Transition zone						
Seismic (*P*-wave)						
Dynamite	9.5	170	7,538	18	793	44
Compressed air	2.6	274	255,092	105	98,112	931
Marine						
Seismic (*P*-wave)						
Compressed air	246.6	141,901	141,496,000	575	573,788	997
3-D Seismic						
Line-miles	59.4	144,577	69,297,000	2,434	1,166,616	479
Gravity	.5	1,000	15,000	2,000	30,000	15
Gravity	.2*	2,500	15,000	10,000*	60,000*	6
Magnetic	.5	1,000	15,000	2,000	30,000	15
Airborne						
Magnetic	3.0	3,125	90,000	1,042	30,000	29
VLF	1.0	1,275	152,861	1,275	152,861	120
Combined EM/Mag.	1.0	1,275	152,861	1,275	152,861	120
Drill hole						
Gravity	.7	(38,000)	135,000	(50,667)	180,000	(4)
EM – freq.	8.5	[5]	3,770	[1]	444	[754]
VSP	21.4	[62]	361,260	[3]	16,881	[5,827]

Table 7. Worldwide average unit costs in 1989 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Africa						
Land						
Seismic (*P*-wave)						
Dynamite	333.4	37,996	116,440,634	114	349,252	3,065
Compressed air	28.0	2,670	13,000,000	95	464,286	4,869
Vibratory	100.1	12,870	40,775,689	129	407,350	3,168
Seismic (refraction)						
Solid chemical	3.0	24	19,000	8	6,333	766
3-D seismic						
Line-miles	5.0	1,476	2,679,699	295	535,940	1,816
Square miles	21.0	270	1,686,313	13	80,301	6,239
Gravity	161.5	20,398	18,775,100	126	116,254	920
Gravity	10.5*	298	20,000	28*	1,905*	67
Magnetic	49.5	9,022	231,019	182	4,667	26
Resistivity	1.0	10	20,000	10	20,000	2,000
EM – freq.	2.5*	31	15,500	13*	6,200*	491
Radiometric						
Gamma ray	2.8	17	5,400	6	1,882	303
Transition zone						
Seismic (*P*-wave)						
Dynamite	5.0	523	1,569,000	105	313,800	3,000
Compressed air	2.9	1,132	2,022,615	390	697,453	1,787
Marine						
Seismic (*P*-wave)						
Compressed air	149.7	78,452	59,818,600	524	399,456	762
3-D seismic						
Line-miles	6.9	25,440	11,962,000	3,687	1,733,623	470
Gravity	5.0	7,500	125,000	1,500	25,000	17
Magnetic	503.4	5,392	80,800	11	161	15
Airborne						
Magnetic	15.5	18,161	1,673,000	1,169	107,658	92
EM – freq.	2.0	1,243	292,000	622	146,000	235
Drill hole						
VLF	.1	(1,312)	400	(32,800)	10,000	(1)
Radiometric						
Gamma ray	2.0	(42,650)	7,000	(21,325)	3,500	(1)
VSPs	2.9	[9]	54,000	[3]	18,621	[6,000]
Middle East						
Land						
Seismic (*P*-wave)						
Dynamite	86.0	4,757	24,377,990	55	283,465	5,124
Vibratory	223.0	29,436	89,897,000	132	403,126	3,054
3-D seismic						
Square miles	5.0	348	350,000	70	70,000	1,006
Gravity	22.0	5,045	3,240,000	229	147,273	642
Marine						
Seismic (*P*-wave)						
Compressed air	3.0	1,060	1,060,000	353	353,333	1,000
Magnetic	12.5	15,587	200,650	1,247	16,052	13
Airborne						
Magnetic	15.0	18,270	649,000	1,218	43,267	36
Drill hole						
Gravity	2.0	(22,000)	90,000	(11,000)	45,000	(4)

Table 7. Worldwide average unit costs in 1989 for petroleum surveys (cont.).

Area, survey type, and method	Total crew months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Far East						
Land						
Seismic (*P*-wave)						
Dynamite	166.9	12,608	45,111,000	76	270,288	3,578
Vibratory	38.3	2,992	8,469,000	78	221,123	2,831
Other	13.9	781	410,000	56	29,496	525
EM - tem.	2.0	200	500,000	100	250,000	2,500
Transition zone						
Seismic (*P*-wave)						
Compressed air	5.0	124	1,840,000	25	368,000	14,839
3-D seismic						
Square miles	8.0	125	7,631,000	16	953,875	61,048
Marine						
Seismic (*P*-wave)						
Compressed air	151.2	81,324	61,142,002	538	404,378	752
3-D seismic						
Line-miles	14.0	33,500	9,900,000	2,393	707,143	296
Gravity	2.5	7,000	95,000	2,800	38,000	14
Gravity	1.0	[1,500]	60,000	[1,500]	60,000	[40]
Magnetic	2.9	8,375	112,500	2,858	38,396	13
Airborne						
Gravity	7.0	7,790	700,000	1,113	100,000	90
Magnetic	10.5	23,125	809,600	2,202	77,105	35
Drill hole						
Gravity	4.5	(16,975)	275,000	(3,731)	60,440	(16)
Magnetic	2.1	(12,600)	117,500	(5,915)	55,164	(9)
VSP	1.2	[4]	24,000	[3]	20,000	[6,000]
Australia/New Zealand						
Land						
Seismic (*P*-wave)						
Dynamite	19.6	2,435	12,995,000	124	663,010	5,337
Vibratory	60.6	9,172	23,275,000	151	384,076	2,538
Gravity	1.4	20	23,700	14	16,573	1,185
VSPs	4.0*	[8]	9,000	[2]*	2,250*	[1,125]
Marine						
Seismic (*P*-wave)						
Compressed air	26.2	40,508	29,814,000	1,546	1,137,939	736
Airborne						
Magnetic	2.0	17,000	365,000	8,500	182,500	21

Table 8. U.S.A. petroleum seismic activity in 1989 by area[1].

Survey type, state	Acquisition costs – US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Land					
Alaska	18,428,852	2,203	2.0	19.4	21.4
Alabama	1,340,000	75	3.5	.0	3.5
Arkansas	2,592,438	469	.0	16.0	16.0
Arizona	423,000	430	.0	5.0	5.0
California	22,352,108	5,416	1.0	72.3	73.3
	(3,800,000)	(94)	(4.0)	(.0)	(4.0)
	[166,000]	[6]	[.0]	[.3]	[.3]
Colorado	4,831,190	1,039	.0	87.9	87.9
Florida	1,081,000	121	1.5	1.0	2.5
Illinois	230,000	46	.0	2.0	2.0
Kansas	1,544,345	877	.0	312.0	312.0
Kentucky	35,000	75	1.0	.0	1.0
Louisiana	12,284,000	5,123	.0	67.8	67.8
	[140,100]	[8]	[.5]	[.0]	[.5]
Michigan	19,187,999	3,650	27.2	57.5	84.7
Mississippi	1,011,000	91	1.5	1.5	3.0
Montana	769,143	141	.0	7.0	7.0
North Dakota	387,820	155	.0	4.0	4.0
Nebraska	112,235	61	.0	51.0	51.0
New Mexico	3,837,127	1,808	.5	37.2	37.7
	[65,700]	[9]	[.7]	[.0]	[.7]
Nevada	2,393,500	260	.0	7.7	7.7
Ohio	280,000	90	.0	2.0	2.0
Oklahoma	15,014,716	5,755	.0	78.7	78.7
Oregon	523,000	35	.0	1.7	1.7
Texas	35,050,203	10,499	14.6	190.9	205.5
	(1,748,000)	(250)	(4.0)	(.0)	(4.0)
	[469,100]	[25]	[2.3]	[.0]	[2.3]
Utah	1,846,721	696	.0	14.0	14.0
Washington	131,000	10	.0	.4	.4
Wyoming	4,175,494	1,364	.0	104.0	104.0
	(200,000)	(35)	(.0)	(.5)	(.5)
Total land	149,861,891	40,491	52.8	1,141.1	1,193.9
	(5,748,000)	(379)	(8.0)	(.5)	(8.5)
	[840,900]	[49]	[3.5]	[.3]	[3.8]
Transition zone					
Alaska	2,750,000	100	.0	7.0	7.0
Louisiana	4,695,000	2,151	.0	10.5	10.5
	(5,000,000)	(4,824)	(.0)	(4.5)	(4.5)
Michigan	60,000	4	.2	..0	.2
North Dakota	480,000	80	.0	3.0	3.0
Total transition	7,985,000	2,335	.2	20.5	20.7
	(5,000,000)	(4,824)	(.0)	(4.5)	(4.5)

(Continued over)

[1] All data enclosed in (parentheses) pertain to 3-D surveys reported in line-miles; all data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 8. U.S.A. petroleum seismic activity in 1989 by area (cont.)[1].

Survey type, state	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Marine					
Off Alaska	2,100,000	3,757	.0	3.5	3.5
Gulf Coast	91,172,900	121,015	30.0	134.0	164.0
	(15,731,000)	(71,650)	(21.0)	(.0)	(21.0)
	[1,450,000]	[4,328]	[1.7]	[.0]	[1.7]
West Coast	5,848,100	1,000	.0	10.0	10.0
Total marine	99,121,000	125,772	30.0	147.5	177.5
	(15,731,000)	(71,650)	(21.0)	(.0)	(21.0)
	[1,450,000]	[4,328]	[1.7]	[.0]	[1.7]
Total U.S.A.	256,967,891	168,598	83.1	1,309.1	1,392.2
	(26,479,000)	(76,853)	(29.0)	(5.0)	(34.0)
	[2,290,900]	[4,377]	[5.3]	[.3]	[5.6]

[1]All data enclosed in (parentheses) pertain to 3-D surveys reported in line-miles; all data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Total 9. Canada petroleum seismic activity in 1989 by area.[1].

Survey type, province	Acquisition costs - US$	Line-miles	Crew-months		Crew-months total*
			Company*	Contract	
Land					
Alberta	114,748,705	28,756	12.5	295.6	308.1
	[11,142,214]	[494]	[.0]	[14.6]	[14.6]
British Columbia	23,183,237	5,528	6.5	65.5	72.0
	[962,000]	[12]	[.0]	[1.5]	[1.5]
Manitoba	41,005	18	.0	.0	.0
Northwest territories	7,229,800	1,053	.0	10.5	10.5
	[4,900,000]	[82]	[.0]	[3.0]	[3.0]
Saskatchewan	7,454,085	2,446	1.0	30.0	31.0
Total land	152,656,832	37,802	20.0	401.8	421.8
	[17,004,214]	[588]	[.0]	[19.1]	[19.1]
Transition					
Northwest territories	300,000	318	.0	.5	.5
Total transition	300,000	318	.0	.5	.5
Marine					
Undesignated	2,695,000	2,275	.0	2.8	2.8
	[417,000]	[15]	[.0]	[.7]	[.7]
British Columbia	1,299,000	300	.0	3.0	3.0
Northwest territories	17,000,000	7,345	.0	7.5	7.5
Total marine	20,994,000	9,920	.0	13.3	13.3
	[417,000]	[15]	[.0]	[.7]	[.7]
Total Canada	173,950,832	48,040	20.0	415.6	435.6
	[17,421,214]	[603]	[.0]	[19.8]	[19.8]

[1]All data enclosed in (parentheses) pertain to 3-D surveys reported in line-miles; all data enclosed in [brackets] pertain to 3-D surveys reported in square miles.
*Total includes government and university activity, if any.

Table 10. Petroleum seismic activity in Mexico in 1989.

Survey type	Acquisition costs - US$	Line-miles	Crew-months		Total months
			Company	Contract	
Land					
Various	13,500,000	7,544	.0	150.0	150.0
Marine					
Various	1,100,000	219	.0	2.0	2.0
Total Mexico	14,600,000	7,763	.0	152.0	152.0

Table 11. Total worldwide expenditures in 1989 on gravity and magnetic surveys in US$ (thousands).

Area	Petroleum		Minerals	Environmental	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
	Exploration	Development								
International		4,750							2,822	7,572
U.S.A.	2,417	42	651	20	47	93	3		248	3,524
Canada	735		1,309						3	2,048
Mexico										
South America	2,643									2,653
Europe	167	2,635	817		640				10	4,265
Africa	2,194	18,710	3,897						5	24,936
Middle East	849	3,330	*		12,000		5		130	16,179
Far East	2,169		929		26	25	139	50		3,339
Australia/ New Zealand	388		3,087	15	18				222	3,732
Total	11,567	29,467	10,692	35	12,732	118	148	50	3,440	68,253

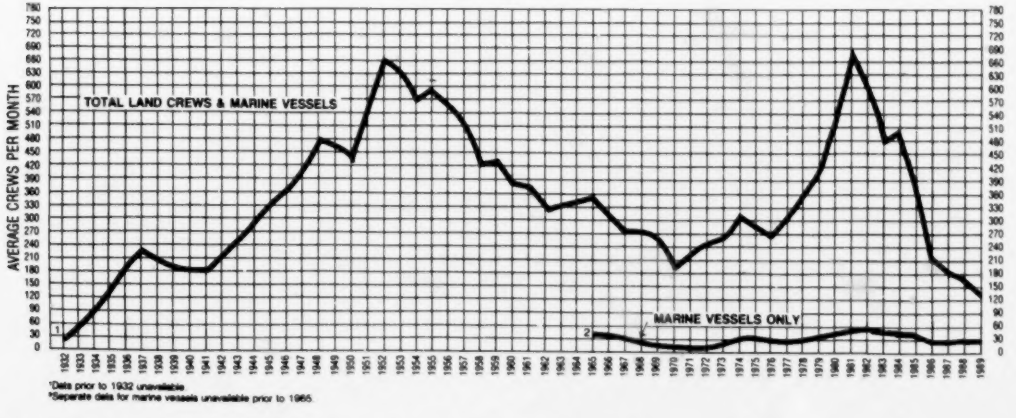
AVERAGE CREWS PER MONTH
TOTAL LAND CREWS & MARINE VESSELS
MARINE VESSELS ONLY
*Data prior to 1932 unavailable
*Separate data for marine vessels unavailable prior to 1966

FIG. 4. History of seismic exploration activity in the U.S., 1932-89. (The total crews working in a given year is not synonymous with the crew-months worked that year.

Table 12. Total worldwide expenditures in 1989 on airborne surveys in US$ (thousands).

Area	Petroleum exploration	Minerals	Environmental	Engineering	Geothermal	Groundwater	Research	Total
International								
U.S.A.	4,572	1,669						6,241
Canada	7,680	4,694	30				200	12,604
Mexico								
South America	2,467							2,467
Europe	395	2,977			143		169	3,686
Africa	1,965	2,400	19					4,384
Middle East	649							649
Far East	1,509	108		26		321		1,965
Australia/ New Zealand	365	3,035					150	3,550
Total	19,604	14,885	49	26	143	321	519	35,549

Table 13A. Western hemisphere airborne activity in 1989 in US$ (thousands).

	USA		Canada		South America	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Gravity	76,316	954	1,361	17		
Magnetic	97,936	1,475	105,704	1,932	81,700	2,173
Electromagnetic - tem			2,700	30		
VLF	8,115	855	33,473	3,666	1,228	147
Combined EM/Mag.	20,244	1,863	69,381	6,678	1,228	147
Radiometric						
Gamma ray	311	32	13,000	280		
Remote sensing						
Multispectral scanning	40,000	300				
Side-looking radar	73,900	760				
Total	316,822	6,241	225,619	12,604	84,156	2,467

Table 13B. Eastern hemisphere airborne activity in 1989 in US$ (thousands).

Survey method	Europe		Africa		Middle East		Far East		Australia/New Zealand	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Gravity							7,790	700		
Magnetic	28,625	95	133,161	3,273	18,270	649	39,032	1,007	230,875	3,431
Electromagnetic - freq			1,242	292			10,625	107		
VLF	1,275	152								
Combined EM/Mag.	3,775	352	13,831	800					1,717	114
Radiometric										
Gamma ray							10,845	151	250	5
Remote sensing										
Multispectral scanning	3,087	308	190	19						
Other	31,697	2,777								
Total	68,459	3,686	148,424	4,384	18,270	649	68,292	1,965	232,842	3,550

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International (−15.5 percent), U.S. (−16.6 percent), and the Middle East (−10.9 percent). Canada increased 19.3 percent, Mexico (+20.3 percent), South America (+24 percent), Europe (+22.8 percent), Africa (+62 percent), the Far East (+26.8 percent) and Australia/New Zealand (+51.6 percent). Petroleum exploration and development increased by 1.3 percent in the Western Hemisphere; Eastern Hemisphere activity rose by 33.6 percent over 1988. A 10-year history of petroleum exploration and development activity in both hemispheres is shown in Figure 1.

Petroleum seismic surveys

The seismic method accounted for 95.5 percent of all expenditures in petroleum geophysical activity. This statistic plus the strong tendency for wildcatting to parallel seismic activity has caused those interested in forecasts of petroleum exploration to regard seismic activity as a barometer for exploration. A 10-year history of the cost of petroleum seismic surveys in both Eastern and Western Hemispheres (usually given in Figure 2) has been dropped this year due to some large and unexplained costs in Mexico which rendered the statistical material questionable. Distribution of expenditures, line-miles, and crew-months for land, transition, and marine are shown in Tables 3, 4B, and 5.

For 1989, dynamite was the most popular land seismic energy source used with vibroseis second. These two sources accounted for 97 percent of all seismic land work in 1989 (see Table 4A). In marine work, the compressed air energy source was the single source reported (see Table 6).

One can refer to Table 7 for a more comprehensive breakdown of statistical data on petroleum surveys, which are sorted by geographical area. Table 8 shows petroleum seismic activity by states in the U.S. where Texas and California accounted for 38 percent of all U.S. onshore expenditures on seismic exploration.

Most of the marine seismic activity in U.S. waters was recorded along the Gulf Coast. The transition zone data reported were from the Gulf Coast, Alaska, Michigan, and North Dakota.

Table 14A. Western hemisphere land mining activity in 1989 in US$ (thousands).

	USA		Canada	
Survey method	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost
Seismic (*P*-wave)				
Dynamite	18	198		
Electrical	7	12		
Seismic (refraction)				
Dynamite	3	25	15	45
Gravity			780	52
Gravity	[5,600]	100		
Magnetic	654	41		
Resistivity	15	23		
Sonic/velocity logging			2,700	30
EM - freq.			90	13
EM - tem.			1,500	196
EM - tem.	[300]	150		
VLF	85	8		
Combined EM/Mag.	617	86		
Induced polarization	269	687	690	82
CSAMT	[640]	180		
Radiometric				
Gamma ray	[262]	5		
Total	1,668	1,081	5,775	418
	[6,802]	435		

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Table 9 shows petroleum seismic activity was up 19.3 percent compared to 19.8 percent for Canada. Table 10 shows Mexico had a 20 percent increase in activity in 1989 over 1988.

A 58-year history of seismic exploration in the U.S. is shown in Figure 5.

Gravity and magnetic surveys

Table 11 shows worldwide expenditures for gravity and magnetic surveys. The 1989 data show 55.4 percent increase in expenditures in these methods as compared to 1988. Expenditures on gravity and magnetic surveys for petroleum exploration and development were up 65 percent while expenditures for minerals was down 20 percent from 1988. Africa was the largest user of these methods in 1989.

Airborne surveys

Statistical data on airborne surveys are shown in Tables 12, 13A, and 13B. Expenditures for worldwide surveys increased by 17 percent from 1988. The major increase was in petroleum exploration which was up 25 percent compared to 1988.

Land mining

Tables 14A and 14B report expenditures and methods utilized for land mining in the Western and Eastern Hemispheres.

Engineering, geothermal, groundwater, oceanography, and research

Table 15 reports engineering and groundwater activity, which showed a 48 percent increase. Table 16 contains worldwide geo-

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Table 14B. Eastern hemisphere land mining activity in 1989 in US$ (thousands).

	Europe		Africa		Far East		Australia/New Zealand	
Survey method	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost	Line-miles (footage) [stations]	Cost
Seismic (*P*-wave)								
Dynamite	151	1,445			60	2,500	115	828
Vibratory	359	229	2,011	6,064				
Passive monitoring			300	500				
Seismic (refraction)								
Dynamite							1	15
Dynamite					[201]	10		
Gravity	46,662	335	25	4	35	53	111	39
Gravity	[27,970]	352	[50]	150	[7,790]	78	[1,394]	38
Magnetic	503	129	76,705	1,959			502	93
Magnetic					[73,218]	733		
Resistivity	90	180	5	10				
Resistivity	[60,000]	1						
Self-potential			124	280				
Self-potential					[54,572]	546		
EM - freq.	95	135	13	22			5	6
EM - freq.					[8,788]	88		
EM - tem.							58	56
EM - tem.							[10]	6
VLF	156	117	30	32				
VLF					[67,833]	680		
Combined EM/Mag.	1,781	704						
Induced polarization	374	293	550	216			272	338
Radiometric								
Gamma ray			410	42				
Alpha track			50	5				
Total	8,171	3,570	80,223	9,136	95	2,553	1,064	1,376
	[87,970]	352	[50]	150	[212,402]	2,135	[1,404]	45

Table 15. Worldwide groundwater and engineering activity in 1989.

Survey method	Area			Time		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic (*P*-wave)						
Dynamite	250	51		1.7		29.0
Compressed air	2,541			109.0		9,900.0
Electrical	900			10.4	1.5	2,287.0
Implosive	200			3.0		1,000.0
Weight drop	2			.2		10.0
Vibratory	4	1		40.2		70.0
Seismic (*S*-wave)						
Other	3			.5		10.0
Seismic (refraction)						
Dynamite	33			3.5	4.5	130.9
Weight drop	40			7.0	2.1	92.6
Solid chemical				.5		40.0
Gravity	12,417	4,143		37.3	1.5	12,721.7
Magnetic	13,442	150		11.4	.9	158.9
Resistivity	592	1,221	18,295	74.0	6.6	1,209.3
Self-potential			29,007		.2	2.2
Sonic/velocity logging			2,652			.1
EM – freq.	10,652			10.0		151.0
EM – tem.	262	600		10.1		479.8
Combined EM/Mag.		500		1.0		75.0
Radiometric						
Gamma ray	10,625		22,179	9.3	.1	116.2
Other	12,205	80	58,290	7.0	16.0	3,317.0
Total	64,170	6,746	130,423	336.5	33.6	31,800.8

Table 16. Worldwide geothermal activity in 1989.

Survey method	Area			Time		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic (*P*-wave)						
Dynamite	248			.2		10.0
Passive monitoring		2			24.0	300.0
Gravity		1,202		9.0		118.0
Resistivity	57			8.0		85.0
EM – freq.	150			3.0		150.0
Magnetotelluric	360	30		9.0		530.0
Remote sensing						
Multispectral scanning	1,439			2.3		143.9
Temperature gradient			2,400	.2		2.0
Other		2		7.0		47.5
Total	2,254	1,236	2,400	38.7	24.0	1,386.4

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method.

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew-month or man-month*	Average cost/ mile or (foot) or [station]
Petroleum exploration						
Land						
Seismic (*P*-wave)						
Dynamite	1,647.1	117,451	457,827,318	71	277,960	3,898
Compressed air	28.1	2,674	13,030,000	95	463,701	4,873
Weight drop	18.5	416	1,989,000	22	107,514	4,781
Vibratory	1,692.9	108,409	317,708,542	64	187,668	2,931
Other	18.6	946	2,060,000	51	110,753	2,176
Seismic (refraction)						
Dynamite	6.0	3,200	8,500,000	533	1,416,667	2,656
Compressed air	1.0	700	3,000,000	700	3,000,000	4,286
Solid chemical	3.0	24	19,000	8	6,333	766
3-D seismic						
Line-miles	20.5	2,021	10,007,699	99	488,180	4,951
Square miles	64.7	1,561	21,397,795	24	330,366	13,702
Gravity	215.9	6,778	553,400	31	2,563	82
Gravity	3.0	[2,150]	270,500	[717]	90,167	[126]
Gravity	10.5*	298	20,000	28*	1,905*	67
Magnetic	78.5	9,070	238,719	116	3,041	26
Magnetic	12.0	[26,000]	950	[2,167]	79	[1]
EM – freq.	2.5*	31	15,500	13*	6,200*	491
EM – tem.	2.0	200	500,000	100	250,000	2,500
Induced polarization	1.3	[95]	308,000	[73]	236,923	[3,242]
Radiometric						
Gamma ray	22.8	32	9,900	1	433	302
VSPs	12.0	[34]	500,000	[3]	41,667	[14,706]
VSPs	4.0*	[8]	9,000	[2]	2,250*	[1,125]
Transition zone						
Seismic (*P*-wave)						
Dynamite	27.5	997	5,841,538	36	212,420	5,859
Compressed air	11.7	2,830	5,230,707	241	445,167	1,848
3-D seismic						
Line-miles	4.5	4,824	5,000,000	1,072	1,111,111	1,036
Square miles	8.0	125	7,631,000	16	953,875	61,048
Marine						
Seismic (*P*-wave)						
Compressed air	785.9	436,641	405,680,602	556	516,166	929
3-D seismic						
Line-miles	101.3	275,167	106,890,000	2,716	1,055,183	388
Square miles	.7	15	417,000	21	595,714	27,800
Gravity	10.0	19,500	300,000	1,950	30,000	15
Gravity	1.0	[1,500]	60,000	[1,500]	60,000	[40]
Gravity	.2*	2,500	15,000	10,000*	60,000*	6
Magnetic	533.7	59,196	639,680	111	1,199	11
Airborne						
Gravity	14.7	57,638	1,323,601	3,910	89,797	23
Magnetic	133.5	260,153	7,753,526	1,948	58,061	30
EM – freq.	2.0	1,243	292,000	622	146,000	235
VLF	35.2	44,091	4,822,072	1,253	136,991	109
Combined EM/Mag.	28.9	36,279	4,353,346	1,255	150,635	120
Remote sensing						
Multispectral scanning	3.0	40,000	300,000	13,333	100,000	8
Side-looking radar	1.2	73,900	760,000	61,583	633,333	10

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Petroleum exploration, cont.						
Drill hole						
Gravity	4.5	(16,975)	275,000	(3,731)	60,440	(16)
Magnetic	2.1	(12,600)	117,500	(5,915)	55,164	(9)
Electromagnetic – freq.	8.5	[5]	3,770	[1]	444	[754]
VLF	.1	(1,312)	400	(32,800)	10,000	(1)
Radiometric						
Gamma ray	2.0	(42,650)	7,000	(21,325)	3,500	(1)
VSP	27.5	[81]	475,260	[3]	17,282	[5,867]
Petroleum development						
Land						
Seismic (*P*-wave)						
Dynamite	30.3	1,668	11,100,046	55	365,735	6,655
Vibratory	35.1	3,503	20,150,000	100	574,074	5,751
Vibratory	3.0	[5]	100,000	[2]	33,333	[20,000]
3-D seismic						
Line-miles	4.0	250	1,748,000	63	437,000	6,992
Square miles	2.7	34	488,900	13	181,074	14,049
Gravity	83.0	30,336	29,200,000	365	351,807	963
Resistivity	15.0	150	300,000	10	20,000	2,000
Transition zone						
Seismic (*P*-wave)						
Compressed air	7.0	1,049	2,907,000	150	415,286	2,771
Marine						
Seismic (*P*-wave)						
Compressed air	43.6	65,470	32,277,000	1,502	740,298	493
3-D seismic						
Square miles	1.7	4,328	1,450,000	2,473	828,571	335
Drill hole						
Gravity	3.2	(66,000)	267,500	(20,308)	82,308	(4)
Minerals						
Land						
Seismic (*P*-wave)						
Dynamite	23.0	344	4,971,578	15	216,156	14,452
Electrical	.5	7	12,000	15	24,000	1,600
Vibratory	39.6	2,370	6,293,520	60	158,927	2,655
Passive monitoring	24.0	300	500,000	13	20,833	1,667
Seismic (refraction)						
Dynamite	1.7	19	85,000	11	48,571	4,359
Dynamite	1.0	[201]	10,000	[201]	10,000	[50]
Gravity	126.7	5,301	275,400	42	2,173	52
Gravity	84.0	[35,810]	580,217	[426]	6,907	[16]
Gravity	36.2*	312	210,355	9*	5,803*	674
Gravity	14.0*	[6,994]	138,700	[500]	9,907*	[20]
Magnetic	27.8	77,849	2,085,100	2,799	74,977	27
Magnetic	44.0	[73,218]	733,000	[1,664]	16,659	[10]
Magnetic	23.5*	518	138,080	22*	5,876*	267
Resistivity	10.5	110	213,000	10	20,286	1,936
Resistivity	22.0	[60,000]	620	[2,727]	28	[1]

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs – US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/ mile or (foot) or [station]
Minerals, Land, cont.						
Self-potential	2.0	124	280,000	62	140,000	2,253
Self-potential	51.0	[54,572]	546,000	[1,070]	10,706	[10]
Sonic/velocity logging	1.0	2,700	30,000	2,700	30,000	11
EM – freq.	12.9	148	101,300	11	7,810	684
EM – freq.	8.0	[8,788]	88,000	[1,099]	11,000	[10]
EM – freq.	10.0*	55	75,902	6*	7,590*	1,380
EM – tem.	152.9	1,558	252,000	10	1,647	162
EM – tem.	3.1	[310]	156,500	[98]	49,369	[505]
VLF	4.5	115	40,500	25	8,862	352
VLF	47.0	[67,833]	680,000	[1,443]	14,468	[10]
VLF	20.0*	156	117,346	8*	5,867*	752
Combined EM/Mag.	1.2	617	86,600	502	70,407	140
Combined EM/Mag.	120.0*	1,781	704,075	15*	5,867*	395
Induced polarization	107.6	1,781	1,323,800	17	12,296	743
Induced polarization	50.0*	374	293,364	7*	5,867*	784
CSAMT	4.4	[640]	180,000	[143]	40,268	[281]
Radiometric						
Gamma ray	6.0	410	42,000	68	7,000	102
Gamma ray	1.0	[262]	5,000	[262]	5,000	[19]
Alpha track	.8	50	5,500	60	6,627	110
Marine						
Magnetic	11.5	14,243	183,000	1,239	15,913	13
Airborne						
Gravity	4.3	27,829	348,141	6,427	80,402	13
Magnetic	178.4	416,431	5,995,946	2,333	33,594	14
EM – tem.	1.0	2,700	30,000	2,700	30,000	11
Combined EM/Mag.	62.4	73,897	5,602,762	1,184	89,788	76
Radiometric						
Gamma ray	2.4	2,781	131,488	1,140	53,889	47
Other	6.0	31,697	2,777,129	5,283	462,855	88
Drill hole						
Magnetic	.5	(4,000)	5,000	(8,000)	10,000	(1)
EM – freq.	8.2	[25]	191,100	[3]	23,305	[7,644]
EM – tem.	1.6	(19,000)	19,000	(11,875)	11,875	(1)
Combined EM/Mag.	1.0	(8,000)	6,000	(8,000)	6,000	(1)
Induced polarization	2.9	(40,000)	45,100	(13,378)	15,084	(1)
Radiometric						
Gamma ray	1.2	(14,000)	9,000	(11,667)	7,500	(1)
Environmental						
Land						
Seismic (*P*-wave)						
Dynamite	.5	2	36,000	5	72,000	14,400
Gravity	2.0	1	10,000	1	5,000	6,667
Gravity	.5*	[400]	2,700	[800]	5,400*	[7]
Magnetic	1.6	92	17,100	55	10,240	185
Magnetic	.5*	[80]	6,000	[160]	12,000*	[75]
Resistivity	4.0*	10	13,000	3*	3,250*	1,300
Self-potential	.1	1	1,000	40	33,333	833
Self-potential	6.0*	8	17,000	1*	2,833*	2,125

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Environmental, Land, cont.						
EM - freq.	1.3	18	32,850	14	24,699	1,766
EM - tem.	.2	45	4,500	180	18,000	100
Radiometric						
Gamma ray	.1	3	600	103	20,000	194
Remote sensing						
Other	23.0	44	27,500	2	1,196	625
Other	1.5*	15	28,000	10*	18,667*	1,867
Other	1.5*	[130]	30,000	[87]	20,000*	[231]
Airborne						
Radiometric						
Gamma ray	.2	1,000	30,000	5,000	150,000	30
Remote sensing						
Multispectral scanning	1.0	190	19,000	190	19,000	100
Drill hole						
Resistivity	.1*	(421)	100	(42,100)	10,000*	(1)
Self-potential	.1*	(421)	100	(42,100)	10,000*	(1)
Radiometric						
Gamma ray	.1*	(1,411)	100	(141,100)	10,000*	(1)
Engineering						
Land						
Seismic (*P*-wave)						
Dynamite	1.0	2	14,000	2	14,000	7,000
Dynamite	.5	[51]	5,000	[102]	10,000	[98]
Weight drop	.2	2	10,000	8	40,000	5,000
Vibratory	.2	4	60,000	16	240,000	15,000
Vibratory	40.0	[1]	10,000	[1]	250	[10,000]
Seismic (*S*-wave)						
Other	.5	3	10,000	6	20,000	3,333
Seismic (refraction)						
Dynamite	2.5	17	70,000	7	28,000	4,118
Dynamite	4.5*	9	39,970	2*	8,882*	4,441
Weight drop	7.0	29	40,800	4	5,771	1,378
Weight drop	1.6*	9	36,850	6*	22,888*	4,005
Solid chemical	.5	1	40,000	1	80,000	80,000
Gravity	35.1	12,392	12,658,920	353	360,345	1,022
Gravity	1.0*	[500]	22,800	[500]	22,800*	[46]
Magnetic	.1	3	900	30	9,000	300
Magnetic	.5*	[150]	12,000	[300]	24,000*	[80]
Resistivity	6.7	58	119,000	9	17,630	2,034
Resistivity	.1	[10]	500	[333]	16,667	[50]
Resistivity	.5*	1	8,000	2*	16,000*	8,000
EM - freq.	.5	2	40,000	4	80,000	20,000
EM - tem.	.9	12	19,800	13	22,000	1,650
Combined EM/Mag.	1.0	[500]	75,000	[500]	75,000	[150]
Other	.5*	5	5,000	10*	10,000*	1,000
Other	1.5*	[80]	22,000	[53]	14,667*	[275]

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Engineering, cont.						
Marine						
Seismic (*P*-wave)						
Compressed air	109.0	2,541	9,900,000	23	90,826	3,895
Electrical	10.4	860	2,222,000	83	213,654	2,584
Electrical	1.5*	40	65,000	27*	43,333*	1,625
Implosive	3.0	200	1,000,000	67	333,333	5,000
Seismic (refraction)						
Weight drop	.5*	2	15,000	4*	30,000*	7,500
Magnetic	.3	200	4,000	667	13,333	20
Magnetic	.2*	15	8,000	60*	32,000*	533
Other	7.0	12,200	3,200,000	1,743	457,143	262
Airborne						
Magnetic	2.2	2,594	26,000	1,179	11,818	10
Drill hole						
Other	1.5*	(4,000)	30,000	(2,667)	20,000*	(8)
Geothermal						
Land						
Seismic (*P*-wave)						
Dynamite	.2	248	10,000	994	40,000	40
Passive monitoring	24.0*	[2]	300,000	[1]	12,500*	[150,000]
Gravity	9.0	[1,202]	118,000	[134]	13,111	[98]
Resistivity	8.0	57	85,000	7	10,625	1,486
EM - freq.	3.0	150	150,000	50	50,000	1,000
Magnetotelluric	7.0	360	430,000	51	61,429	1,194
Magnetotelluric	2.0	[30]	100,000	[15]	50,000	[3,333]
Other	7.0	[2]	47,500	[1]	6,786	[23,750]
Airborne						
Remote sensing						
Multispectral scanning	2.3	1,439	143,900	618	61,760	100
Drill hole						
Temperature gradient	.2	(2,400)	2,000	(12,000)	10,000	(1)
Groundwater						
Land						
Seismic (*P*-wave)						
Dynamite	.2	248	10,000	994	40,000	40
Seismic (refraction)						
Dynamite	1.0	7	21,000	7	21,000	3,000
Gravity	.7	25	4,000	33	5,333	160
Gravity	1.5	[3,243]	32,500	[2,162]	21,667	[10]
Gravity	.5*	[400]	3,500	[800]	7,000*	[9]
Magnetic	.1*	5	1,000	29*	5,882*	200
Resistivity	53.2	532	1,065,000	10	20,000	2,000
Resistivity	14.0	[1,100]	430	[79]	31	[1]
Resistivity	6.0*	[111]	15,000	[19]	2,500*	[135]
EM - freq.	.7	25	4,000	33	5,333	160
EM - tem.	1.2	250	25,000	200	20,000	100
EM - tem.	8.0	[600]	435,000	[75]	54,375	[725]

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method (cont).

Survey objective, type and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Groundwater, cont.						
Airborne						
Magnetic	8.8	10,625	107,000	1,207	12,159	10
EM - freq.	8.8	10,625	107,000	1,207	12,159	10
Radiometric						
Gamma ray	8.8	10,625	107,000	1,207	12,159	10
Drill hole						
Resistivity	.1*	(18,295)	1,400	(107,618)*	8,235*	(1)
Self-potential	.2*	(29,007)	2,200	(107,433)	8,148*	(1)
Sonic/velocity logging	.1*	(2,652)	100	(132,600)	5,000*	(1)
Radiometric						
Gamma ray	.5	(5,412)	8,000	(10,408)	15,385	(1)
Gamma ray	.1*	(16,767)	1,200	(111,780)	8,000*	(1)
Other	12.5*	(54,290)	60,000	(4,343)	4,800*	(1)
Oceanography						
Marine						
Seismic (*P*-wave)						
Compressed air	5.0*	3,600	44,000	720*	8,800*	12
Electrical	1.0	322	10,000	322	10,000	31
Other	.5	30	7,000	60	14,000	233
Magnetic	4.4	5,309	50,000	1,207	11,364	9
Remote sensing						
Multispectral scanning	10.0*	10,900	109,000	1,090*	10,900*	10
VSP	60.0*	18,000	4,800,000	300*	80,000*	267
Research						
Land						
Seismic (*P*-wave)						
Dynamite	2.0	10	22,000	5	11,000	2,200
Dynamite	.5	[288]	7,250	[497]	12,500	[25]
Vibratory	4.4	154	616,000	35	140,000	4,000
Passive monitoring	36.0	450	750,000	13	20,833	1,667
Seismic (*S*-wave)						
Dynamite	.5	[288]	7,250	[497]	12,500	[25]
Seismic (refraction)						
Dynamite	1.2	653	211,500	545	176,250	324
Dynamite	.3	[192]	7,000	[582]	21,212	[36]
Weight drop	.1	1	200	10	4,000	400
Weight drop	1.0	[2,000]	40,000	[2,000]	40,000	[20]
Gravity	3.5	454	113,500	130	32,429	250
Gravity	35.0	[9,806]	328,141	[280]	9,375	[33]
Gravity	.5*	40	7,000	77*	13,462*	175
Gravity	9.0*	[566]	6,500	[63]	722*	[11]
Magnetic	.5*	35	5,000	70*	10,000*	143
Resistivity	.2	25	2,500	100	10,000	100
Other	12.0	[57]	124,000	[5]	10,333	[2,175]
Other	4.0*	[11]	24,000	[3]	6,000*	[2,182]

Table 17. Worldwide average unit costs in 1989 by survey objective, type, and method (cont).

Survey objective, type, and method	Total crew-months or man-months*	Miles or (footage) or [stations]	Acquisition costs - US$	Average miles or (footage) or [stations]/ crew-month or man-month*	Average cost/ crew month or man-month*	Average cost/mile or (foot) or [station]
Research, cont.						
Marine						
Seismic (*P*-wave)						
Compressed air	11.0	24,126	1,756,116	2,193	159,647	73
Gravity	8.0	55,198	1,488,330	6,900	186,041	27
Magnetic	6.0	45,672	1,333,969	7,612	222,328	29
Other	4.0	17,077	3,000,000	4,269	750,000	176
Airborne						
Magnetic	6.5	45,500	155,000	7,000	23,846	3
Radiometric						
Gamma ray	1.7	10,000	200,000	5,882	117,647	20
Remote sensing						
Multispectral scanning	1.2	1,648	164,800	1,318	131,840	100
Drill hole						
Magnetic	.2	(4,000)	3,500	(16,000)	14,000	(1)
Resistivity	.5*	(9,848)	3,000	(19,696)*	6,000*	(1)
Self-potential	.5*	(9,848)	3,000	(19,696)*	6,000*	(1)
Induced polarization	.1	(1,800)	1,500	(18,000)	15,000	(1)
Radiometric						
Gamma ray	5.0*	(89,713)	40,000	(17,943)	8,000*	(1)

(Continued from p. 64)

thermal work, which showed a dramatic change which can be attributed to underreporting for this year. Oceanography showed a 17.5 percent increase with research declining by 50.5 percent.

Summary

All survey objectives reported this year as in all years are held in strictest confidence. From discussions with those companies who choose to participate in the survey, it is still felt that their data can be accessed by anyone. I would like to stress that confidentiality is maintained at all times to prevent this from occurring. As the geophysical industry changes, it is hoped that this committee can continue to maintain high quality controls, ensure complete confidentiality, and strive to improve the report each year.

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Without the faith and trust of all contributors, this report would not be possible. The volume of information that this report strives to analyze is made possible by statistical data provided by companies, contractors, government agencies, and universities. It is gratefully acknowledged that their efforts in organizing their information into the format necessary is a very tedious and time-consuming process and without their efforts there would not be a report.

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